



**Particle Physics Division
Mechanical Department Engineering Note**

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Project Internal Reference: WBS Project 425, Task 1.2.10.5

Project: NOVA

Title: Vertical Slice 5 Test Detector Scintillator Production Procedure

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Key Words: Scintillator

Abstract Summary: Seven separate steps will be used to dissolve wave shifter powder in pseudocumene and diluting the pseudocumene/ wave shift powder mixture with mineral oil to produce the NOvA liquid scintillator.

This procedure describes the equipment and steps used to perform this work.

Applicable Codes: none

Vertical Slice Scintillator

Wave Shifter Dissolve Process and Integration Prototype Detector Scintillator Production

Dave Pushka - FNAL

Originally written on January 20, 2010 for the first effort.

Updated March 31 2010 with changes in blue font for the second effort.

Seven separate steps will be used to dissolve wave shifter powder in pseudocumene and diluting the pseudocumene/ wave shift powder mixture with mineral oil to produce the NOvA liquid scintillator. These steps (at an executive summary level) are:

- 0) Rinse hose, pump and dissolve vessel with pseudocumene.
- 1) Transfer pseudocumene from 55 gallon drum(s) to the 60 gallon dissolve vessel.
- 2) Add wave shifter powder in to the blend vessel.
- 3) Stir pseudocumene in the dissolve vessel to fully dissolve the wave shifter powder
- 4) Move pseudocumene and wave shifter to the 345 gallon tote. Add mineral oil to the pseudocumene and wave shifter blend to produce the liquid scintillator.
- 5) Stir liquid scintillator to achieve a uniform blend
- 6) Transfer scintillator to drums for shipping to vertical slice

Equipment used for these steps are:

One dissolve tank, 60 gallon capacity, 304 stainless steel construction with a 4 inch nominal diameter powder loading hatch, a 1 inch nominal diameter bottom drain, and one ¾" and one 2" top connections.

One electric powered drum pump to transfer the pseudocumene from the delivery drums to the blend tank

One secondary containment vessel to hold the entire contents of the blend tank (already installed under blend tank)

One single speed pseudocumene compatible blend mixer with 2 inch mount. (Installed on dissolve tank 2" top connection).

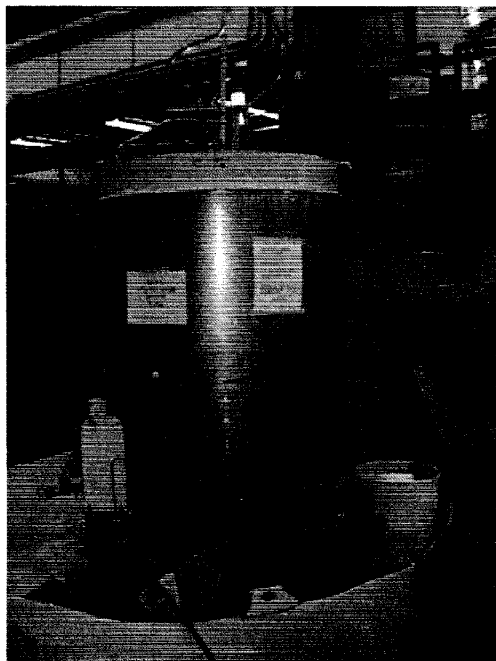
Two pseudocumene compatible liquid transfer hose, ¾" nominal size

Two pseudocumene compatible vapor transfer hoses, ¾" nominal size

One 345 gallon stainless steel tote for diluting the pseudocumene and wave shifter fluor mix with mineral oil to make scintillator.

One electric powered mixer on the 345 gallon stainless steel tote for mixing the scintillator.

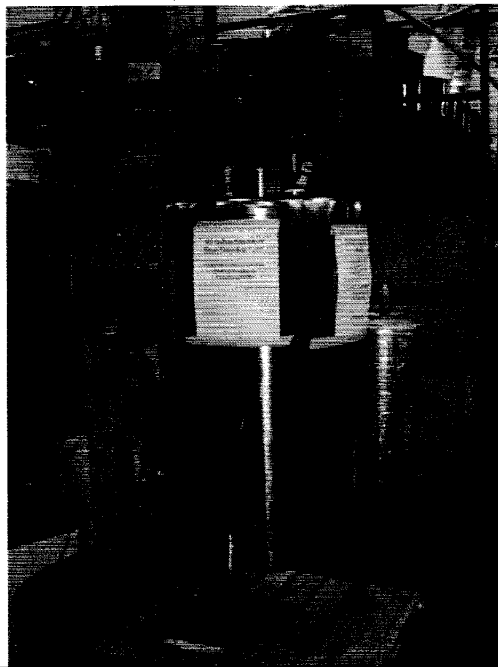
One secondary containment vessel to hold the entire contents of the 345 gallon tote (already installed under 345 gallon tote)



Photograph 1:

345 gallon 304 Stainless steel tote in secondary containment. Vessel sits on load cells used to determine weight of vessel and vessel contents.

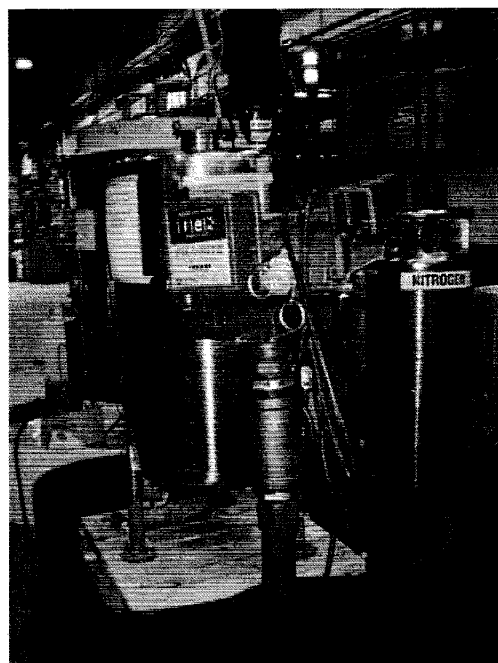
Note: Mixer not yet installed in this image.



Photograph 2:

60 gallon stainless steel dissolve tank with electric mixer installed on the top and sitting on a 1000 pound capacity scale.

Entire assembly (tank, blender, scale) sits in secondary containment.



Photograph 3:

Flammable liquid transfer pump.

Note that this commercial fuel transfer pump has been modified to replace the graphite vanes with Teflon vanes to reduce the potential for contamination of the fluids.

Pump is powered with 110 VAC, single phase power supplied via a GFI outlet.

STEP 0; *Rinse Pump, Hose, and Tank with Pseudocumene.*

- 0a) Inspect to verify the 60 gallon dissolve tank is clean
- 0b) Open one drum of pseudocumene
- 0c) Insert drum pump wand into the 2 inch drum bung hole
- 0d) Connect the ¾ inch nominal diameter pseudocumene liquid transfer hose Durable White Tubing Made with Teflon® FEP ¾" ID, 7/8" OD, 1/16" Wall Thickness) from the drum pump outlet into the top of the dissolve tank.
- 0e) Run a vapor hose (use same FEP material, not PVC) from the blend tank to the ¾ inch bung hole on the pseudocumene drum. This will eliminate the possibility of worker exposure to vapor.
- 0f) Transfer about half a gallon of pseudocumene into the 60 gallon dissolve tank.
- 0g) Drain pseudocumene from 60 gallon dissolve tank and dispose of
- 0h) Close bottom drain valve on 60 gallon dissolve tank

STEP 1; *Transfer the Pseudocumene into the 60 gallon stainless steel dissolve vessel.*

- 1a) Use same set up as in step 0. Record 'tare' weight of the dissolve tank.
- 1b) Use pump to move pseudocumene out of drum and into the 60 gallon dissolve vessel. Operate pump until the pseudocumene drum is empty or until the scale on the dissolve tank indicates the correct amount of pseudocumene has entered the dissolve tank.
- 1c) Read and record-scale weight.
- 1d) If too much pseudocumene is in the dissolve tank, drain out the appropriate amount via the bottom drain. Record weight of the dissolve tank and fluid. Subtract tare weight and compare weight of pseudocumene to the specified value. Adjust as needed.
- 1e) Repeat steps 1b thru 1d until the proper amount of pseudocumene has been transferred into the blend tank. Step 1d may have to be modified so as not to fully empty the last pseudocumene drum.
- 1f) Disconnect vapor hose and cap hose, replace plug in $\frac{3}{4}$ inch drum bung. Join hose ends to maintain cleanliness. Cap and or plug pump connections. Install plug on dissolve vessel top fill connection.
- 1g) Remove drum pump liquid outlet hose and replace 2 inch drum bung.
- 1f) To keep track of the inventory of pseudocumene, Record weight of pseudocumene removed from any opened but not emptied drum. .

STEP 2; *Loading the Wave Shifting Powder*

- 2b) Weigh the blend vessel to establish a tare weight (vessel sits on scale, so this means recording the 'tare' weight). 153.5 to 154.0 pounds
- 2c) Open the top port of the blend vessel and lower the appropriate quantity of wave shifting powder into the vessel. Do not rinse the residue from the wave shifting powder container (this was not done previously; this sentence just explicitly states that the containers will not be rinsed).
- 2d) Close the top port of the blend vessel (use a Teflon gasket instead of the buna-N gasket).

STEP 3; *Stir Circulate Pseudocumene in 60 gallon Blend Vessel.*

- 3a) Turn on drum mixer installed on 60 gallon dissolve tank
- 3b) Allow drum mixer to operate for 60 minutes to ensure adequate time for the wave shifting powder to dissolve and achieve a homogeneous blend.
- 3c) Turn off drum mixer
- 3d) Draw an 8 ounce sample of the pseudocumene and wave shifter mixture (fluor mix) from the bottom of the tank
- 3e) Send sample to IU for analysis
- 3f) When fluor mix is deemed correct, continue with step 4 below. This may take up to two weeks.

STEP 4; *Transfer PS and waveshifter fluor mixture to 345 gallon Tote and Dilute with Mineral Oil*

- 4a) Connect suction side of the flammable liquid pump to the bottom drain of the 60 gallon dissolve vessel using FEP hose
- 4b) Connect the discharge of the flammable liquid pump to the top of the 345 gallon tote using FEP hose
- 4c) Connect the ¾ inch nominal diameter FEP hose between the vents on the 60 gallon dissolve tank and the 345 gallon tote for vapor. This will eliminate the possibility of worker exposure to vapor from the blend tank.
- 4d) Run the flammable liquid transfer pump until 60 gallon blend vessel is empty.
- 4e) Read and record scale weight for both the scale below the 60 gallon dissolve tank and the 345 gallon tote.
- 4g) Remove pump suction line from 60 gallon dissolve tank and attach to a wand inserted into the 2 inch bung hole of the first mineral oil drum.
- 4h) Remove vent line from 60 gallon dissolve tank and attach to a nipple mounted on the ¾ inch bung hole of the first mineral oil drum.
- 4i) Operate pump to transfer mineral oil until drum is empty or the proper weight is indicated on the 345 gallon tote scale.
- 4j) Disconnect vapor hose and cap hose, replace plugs in ¾ inch vessel connections (both 345 gallon vessel and the mineral oil drums).
- 4k) Remove flammable liquid pump, lines, and replace caps and plugs on hoses, pump, and drum connections.
- 4l) Read and record Tote weight. Subtract tote weight from step 4e. Calculate amount of mineral oil added. Compare to specified value.

Step 5; *Stir Liquid Scintillator to Achieve a Uniform Blend in the 345 gallon tote.*

- 5a) Turn on the mixer installed on the tote. Record time.
- 5b) Allow drum mixer to operate for 60 minutes to ensure adequate time to achieve a homogeneous blend
- 5c) Turn off the drum mixer.
- 5d) Take liquid sample from the tote drain port. Send to IU for them to perform QC/QA testing on it.
- 5e) When scintillator mix is deemed correct, continue with step 6 below. This may take up to two weeks.

Step 6; *Transfer Liquid Scintillator to drums for shipping to Caltech.*

- 6a) Connect suction side of the flammable liquid pump to the internal dip tube on the top of the 345 gallon tote using FEP hose.
- 6b) Connect the discharge of the flammable liquid pump to a nozzle inserted into the top of an empty 55 gallon drum using FEP hose.
- 6c) Connect the $\frac{3}{4}$ inch nominal diameter FEP hose between the vents on the 345 gallon tote and the drum for vapor. This will eliminate the possibility of worker exposure to vapor from the blend tank.
- 6d) Run the flammable liquid transfer pump until about 55 gallons has been transferred into a drum. Stop pump. Move nozzle and vent to another drum, close bungs on filled drum and repeat.
- 6e) Continue until the level of scintillator in the 345 gallon tote falls below the bottom of the internal dip tube and pump ceases to remove liquid from the tote.
- 6f) Last few gallons remaining in the tote will need to be removed via the small diameter tote drain line using the flammable liquid pump. Move flammable pump suction connection from top of the 345 gallon tote to the small bottom drain line. Continue until the tote is empty.
- 6g) Disconnect vapor hose and cap hose, replace plugs in $\frac{3}{4}$ inch vessel connections (both 345 gallon vessel and the scintillator drums).
- 6h) Remove flammable liquid pump, lines, and replace caps and plugs on hoses, pump, and drum connections.
- 6i) Label drums, fill out material move, attach MSDS.

From Stuart and Anna, the quantities for the vertical slice scintillator are:

component	volume (gal)	mass (g)
mineral oil	0.951	981.731.4
pseudocumene	0.0484	51.630.33
PPO	0.00086	1.138.176
bis-MSB	0.000014	15.8998
Stadis-425	0.000003	10.3258
Total	320.000	1.034,527.3

Step	Initial Tank Weight, kg	Mass Added, kg	Final Tank Weight, kg	Initial Tank Weight, pounds	Mass Added, pounds	Final Tank Weight, pounds
0, Empty 60 gallon vessel		n/a		153.5	n/a	153.5
1, Add Pseudo- cumene to 60 gallon dissolve vessel.		51.63033		153.5	113.82	267.32
2a, Add PPO to 60 gallon vessel		1.136176		267.32	2.5048	269.82
2b, Add bis-MSB to 60 gallon vessel		0.0158998		269.82	0.0351	269.85
3, Add Pseudo- cumene and wave shifter mix to 345 gallon tote.				684.0	116.3599	800.36
4, Add Mineral Oil to 345 gallon tote.		981.731		800.36	2164.34	2964.69
5, Add Stadis- 425		0.003		2964.69	0.006	2964.70

Calculations to estimate the volume of liquids for comparison to the volume of the vessels. Note that quantities are measured by mass (weight) and not by volume.

Using mineral oil specific gravity of 0.87, calculate the volume for reference:

$$981.731 \text{ kg} * 2.204 \text{ pounds/kg} * (1/62.4 \text{ pounds per cubic foot} * .87) * (1728 \text{ in}^3 / \text{cu. Ft}) * (1 \text{ gallon} / 231 \text{ in}^3) = 298.14 \text{ gallons}$$

Using pseudocumene specific gravity of 0.87, calculate the volume for reference:

$$51.63033 \text{ kg} * 2.204 \text{ pounds/kg} * (1/62.4 \text{ pounds per cubic foot} * .87) * (1728 \text{ in}^3 / \text{cu. Ft}) * (1 \text{ gallon} / 231 \text{ in}^3) = 15.6799 \text{ gallons}$$

Using mineral oil specific gravity of 0.88, calculate the volume for reference:

$$981.731 \text{ kg} * 2.204 \text{ pounds/kg} * (1/62.4 \text{ pounds per cubic foot} * .88) * (1728 \text{ in}^3 / \text{cu. Ft}) * (1 \text{ gallon} / 231 \text{ in}^3) = 294.7600 \text{ gallons}$$

Using pseudocumene specific gravity of 0.88, calculate the volume for reference:

$$51.63033 \text{ kg} * 2.204 \text{ pounds/kg} * (1/62.4 \text{ pounds per cubic foot} * .88) * (1728 \text{ in}^3 / \text{cu. Ft}) * (1 \text{ gallon} / 231 \text{ in}^3) = 15.5018 \text{ gallons}$$

The next several pages are labels used to mark the vessels at each appropriate step so that the contents (or previous contents if the vessel is empty) are identified. This practice is necessary to conform to FESHM 8031.

Vessel contains NOvA
Liquid Scintillator:

~ 95 % mineral oil
(Renoil 70-T)

~ 5% pseudocumene with
dissolved wave shifting
powder.

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EMPTY VESSEL

Formally contained pseudocumene with
dissolved wave shifting powder.

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EMPTY DRUM

Formally contained mineral oil
(Renoil 70-T).

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31 March 2010

PARTIALLY FULL VESSEL

Contains pseudocumene
and dissolved wave
shifting powders (fluor
mix).

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31 March 2010

60 Gallon Stainless Steel Dissolve Tank

Used for Dissolving Wave
Shifting Powder in
Pseudocumene.